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(54) Title: WATER AND UV DEGRADABLE LACTIC ACID POLYMERS

(57) Abstract

A water and UV light degradable copolymer of monomers of lactic acid and a modifying monomer selected from the class consisting of ethylene and polyethylene glycols, propylene and polypropylene glycols, p-dioxanone, 1,5-dioxepan-2-one, 1,4-oxathialan-2-one, 1,4-dioxide and mixtures thereof. These copolymers are useful for waste disposal and agricultural purposes. Also disclosed is a water degradable blend of polylactic acid or modified polylactic acid and high molecular weight polyethylene oxide wherein the high molecular weight polyethylene oxide is present in the range of from about 2 % by weight to about 50 % by weight, suitable for films. A method of applying an active material selected from the class of seeds, seedlings, pesticides, herbicides, fertilizers and mixtures thereof to an agricultural site is also disclosed.

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WATER AND UV DEGRADABLE LACTIC ACID POLYMERS

CONTRACTUAL ORIGIN OF THE INVENTION

The United States Government has rights in this invention pursuant to Contract No. W-31-109-ENG-38 between the U.S. Department of Energy and The University of Chicago, representing Argonne National Laboratory.

Background Of The Invention

The invention relates to modified polymers and polymer blends useful for waste disposal or for agricultural purposes to provide water or UV degradable materials which are environmentally safe. The materials are designed to degrade upon exposure to water or to UV light to environmentally safe naturally occurring materials. The modified polymers and polymer blends when used are also usable for garbage bags or other waste disposal purposes can be incinerated since upon burning only environmentally safe materials are produced.

It is now recognized that many plastic materials useful for packaging as well as waste disposal present serious environmental problems because they either do not degrade in landfills or produce toxic components upon incineration.

More and more attention has been devoted to environmentally safe plastic materials, particularly since Congressional hearings have determined that over 135 thousand metric tons per year of plastic is discarded at sea alone with some 639,000 plastic containers and bags tossed into the ocean every day. In addition to this intolerable situation, the amount of plastic materials used for packaging as well as garbage disposal which do not degrade has caused landfill areas previously thought to be entirely adequate for urban disposal sites to become filled and unusable. Waste disposal has become a very serious problem in this country as well as world-wide.

Accordingly, there is a need to provide plastic materials suitable for packaging and waste disposal which at the same time will also be biodegradable to products which are environmentally safe.

Recently, it has been determined that high carbohydrate waste presently produced in the United States as cheese whey and in conjunction with potato processing facilities is convertible in an environmentally benign process to provide a feed stream for lactic acid. Lactic acid is desirable because it is a naturally occurring compound which degrades to environmentally safe products. In addition, it has been discovered that oligomers of polylactic acid are useful as plant growth promoters, see U.S. patent no. 4,813,997 to Kinnersley et al., issued March 21, 1989. With the discovery by Kinnersley et al. and the conversion of high carbohydrate food waste to feedstocks for lactic acid, a result of research at Argonne National Laboratory, it has become feasible through the present invention to formulate various copolymers and blends of polylactic acid for a wide range of agricultural and packaging uses which meet all the objectives set forth above and provide environmentally safe materials to replace presently used plastics that are difficult to dispose of in a safe manner.

Accordingly, it is an object of the invention to provide water and/or UV light degradable modified polylactic acid polymers or blends thereof useful for the agricultural and/or packaging and/or waste disposal industries.

Another object of the invention is to provide water degradable or UV light degradable polylactic acid polymers and copolymers which may be used as agricultural coatings and mulches which degrade in

the field to provide environmentally safe materials as well as plant growth promoters.

Another object of the invention is to provide a water degradable modified polylactic acid polymer comprising a copolymer of monomers of lactic acid and a modifying monomer selected from the class consisting of ethylene and polyethylene glycols, propylene and polypropylene glycols, p-dioxanone, 1,5 dioxepan-2-one, 1,4 - oxathialan-2-one, 4,4-dioxide and mixtures thereof, wherein the ethylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein the propylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein the p-dioxanone, 1,5 dioxepan-2-one or the 1,4-oxathialan-2-one, 4,4-dioxide is present in the range of from about 2% by weight to about 40% by weight, the modifying polymer not exceeding about 40% by weight of the modified polylactic acid copolymer.

A still further object of the invention is to provide a water and UV degradable polylactic acid polymer comprising a co-polymer of polylactic acid and a modifying monomer selected from the class consisting of p-dioxanone present in an amount up to about 20% by weight, 1,5 dioxepan-2-one present in an amount up to about 20% by weight, and 1,4 oxathialan-2-one, 4,4 dioxide present in an amount up to about 20% by weight, or mixtures thereof, the modifying monomer being present in an amount not greater than about 20% by weight.

Still another object of the invention is to provide a water degradable polylactic acid polymer comprising an alloy of polylactic acid and high molecular weight polyethylene oxide wherein the high molecular weight polyethylene oxide is present in the range of from about 2 to about 50% by weight.

A final object of the invention is to provide a method of applying an active material selected from the class of seeds, seedlings, pesticides, herbicides, fertilizers and mixtures thereof of an to agricultural site comprising providing a copolymer of monomers of lactic acid and a modifying monomer selected from the class consisting of ethylene and polyethylene glycols, propylene and polypropylene glycols, p-dioxanone, 1,5 dioxepan-2-one, 1,4-oxathialan-2-one, 4,4-dioxide and mixtures thereof, wherein the ethylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein the propylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein the p-dioxanone, 1,5 dioxepan-2-one or the 1,4-oxathialan-2-one, 4, 4-dioxide is present in the range of from about 2% by weight to about 40% by weight, the modifying polymer not exceeding about 40% by weight of the modified polylactic acid polymer, forming a combination of the copolymer and the active ingredients wherein the active ingredients are present in the range of from about 60% to about 98% by weight of the combination, and applying the combination to the agricultural site.

The invention consists of certain novel features and a combination of parts hereinafter fully described, and particularly pointed out in the appended claims, it being understood that various changes in the details may be made without departing from the spirit, or sacrificing any of the advantages of the present invention.

Detailed Description Of The Invention

Polymers and copolymers of lactic acid are transparent, colorless thermoplastics with a wide range of physical properties that mimic those of many conventional thermoplastics. When exposed to

moisture or biological fluids, these modified plastics hydrolyze slowly, over a period of several months to natural, harmless, materials such as lactic acid. The copolymers of lactic acid and glycolic acid were originally developed and marketed as an industrial product as resorbable sutures. These polymers and copolymers have high strength and biocompatibility and have controlled degradability.

Poly (lactic acid) and poly (glycolic acid) can be prepared by either condensation polymerization of the free acids or by catalytic, ring-opening polymerization of the dilactones. Both polylactic acid and polyglycolic acid are environmentally compatible because they degrade respectively to lactic acid and glycolic acid, both natural harmless products. While these polymers degrade primarily by hydrolysis, with the addition of certain other materials, they may degrade also by exposure to sunlight or any other source of UV light. Upon incineration, the polymers burn with a clean blue flame, rather than giving off poisonous or corrosive gases as many plastics do.

The fact that the thermoplastics based on a lactic acid polymer degrade slowly over a period of several weeks up to about one year leads to another important advantage of relatively good shelf life. Compared to water-soluble or water-swelled polymers, which fall apart quickly in water, the modified polylactic acid polymers can be classified as moisture sensitive because they degrade only slowly. For instance, after month's immersion in water, polylactic acid and certain of the copolymers thereof show no degradation of the molecular weight. But after six months, physical properties drop significantly. For instance, water degradable modified polylactic acid copolymers may be made from

monomers of lactic acid and modifying monomers selected from the class consisting of ethylene and polyethylene glycols, propylene and polypropylene glycols, p-dioxanone, 1,5 dioxepan-2-one, 1,4-oxathialan-2-one, 4,4-dioxide and various mixtures thereof. The physical properties such as crystallinity, melting point, degradation rate, elasticity and the like can be varied depending upon the amount and the type of copolymer formed.

The elasticity of the material will vary from glassy materials which are relatively nonelastic to high-modulus elastic materials, and the degradation rates will vary from intermediate to fast to very slow to none depending upon the amounts of polylactic acid or polyglycolic acid utilized.

In general, the various physical attributes discussed above can be varied among a wide range of physical properties depending upon the types and amounts of copolymers used for the final material, it being important that depending upon the end usage desired that the modifying polymer for the polylactic acid be present in the range from about 5% by weight to about 40% by weight so as to provide a water degradable modified polylactic acid copolymer which has suitable physical properties for the end use selected.

It is contemplated that the various copolymers of polylactic acid may be useful for a variety of agricultural and waste management uses. For instance, the copolymers may be used as coatings on or as matrices for seeds, seedlings, pesticides, herbicides, fertilizers and mixtures thereof, wherein the coating or matrices provide a controlled release of the coated or embedded material depending upon the thickness of the coating or percent of active ingredient embedded in the matrix. The coatings may

have a thickness in the range of from about 0.25 microns to about 4 microns, so that release rates can be varied as required. The active ingredients, such as seeds, pesticides, herbicides, fertilizers or mixtures thereof also may be mixed with the copolymer and extruded as pellets, with the active ingredient dispersed in a matrix of the copolymer. Here, the release of active ingredients will be controlled by varying the type of copolymer and the amount thereof present. It is preferred that where the copolymer is used as a matrix for an active ingredient, it is present in the range of from about 2% to about 40% by weight, that is, the active ingredient is present in the range of from about 60% to about 98%. Accordingly, it is seen that fertilizers, for instance such as urea or other nitrogen rich fertilizers can be coated with various thicknesses of coating or dispersed in a matrix to provide a continuing release of the coated or dispersed materials over a wide range of time so as to prevent crop burning and other undesirable side effects when too much urea or other fertilizer is released at any one time.

In general, the copolymers of lactic acid are useful with molecular weights in a range of from about 20,000 to about 100,000 for the uses aforesaid as coatings or matrices. Where sheet materials are desired, such as in agricultural mulches and the like, molecular weights of greater than about 25,000 are preferred and in particular, molecular weights in the range from 25,000 to 100,000 are preferred for agricultural mulches which upon time and exposure to moisture and UV light will degrade to the constituent lactic acid and other monomers.

The copolymer, particularly for agricultural use will often be present as a matrix or as a coating for

the active material. Previously, polylactic acid has been used as an encapsulator in the medical field and preparation of encapsulated active materials with polylactic acid coatings has been taught by Ogawa et al. in a paper entitled New Technique to Efficiently Entrap Leuprolide Acetate into Microcapsules of Polylactic Acid or Copoly (Lactic/Glycolic) Acid in Chem. Pharm. Bull. 36(3) 1095-1103 (1988), the disclosure of which is incorporated herein by reference. Further, a process of preparing microcapsules of lactides or lactide copolymers has been patented by Gardner, January 20, 1987, U.S. Patent No. 4,637,905, the disclosure of which is incorporated herein by reference. Similarly, and also in the pharmaceutical field, microencapsulation has been taught by Lapka et al. U.S. patent no. 4,622,244, issued November 11, 1986, the disclosure of which is incorporated herein by reference.

The various modifying monomers which form the new copolymers hereinbefore disclosed, provide a wide range of physical properties from highly crystalline to amorphous materials and from high to low melting point materials, thereby providing controlled degradation rates upon exposure to either UV light or to moisture or to both.

While Sinclair in an article entitled Slow-Release Pesticide System, Polymers of Lactic and Glycolic Acids as Ecologically Beneficial, Cost-Effective Encapsulating Materials, teaches the use of combinations of glycolic and lactic acids as a matrixes for a pesticide, Sinclair does not show or suggest the use of the modified copolymers of lactic acid of this invention. Specifically, the polypropylene glycol and polyethylene glycol used as

modifiers are a different class of materials than the glycolic acid taught by Sinclair.

The present invention permits a copolymer to be designed to control the release rate of the active material to the environment. Where the active material is a high urea content fertilizer, the controlled degradation of the matrix permits the urea to be released at a rate which prevents crop burning and other undesirable side effects. Where the active material is a herbicide or pesticide, the controlled degradation of the matrix permits continual application of the pesticide or herbicide over a prolonged period of time, thereby permitting fewer applications by the farmer and ultimately, releasing less of the active material into the environment since only so much as needed is added at any one time.

It can be seen therefore that increased savings are available to the farmer, both due to fewer applications as well as to administering less of the active material overall. Another added feature and benefit of the present invention is the use of modified polylactic polymers as matrixes or coatings for seeds or seedlings which when germinating or growing are provided with a concentration of growth promoting oligomers of polylactic acid or the disclosed copolymers as the modified polylactic acid copolymer degrades in situ. Whenever the disclosed copolymers degrade in an agricultural site, there will be a variety of oligomers of polylactic acid and copolymers thereof present in a wide variety of chain lengths or molecular weights. Some of these materials are proven growth promoters.

Both agricultural and waste disposal uses require plastic materials for a wide variety of products including, inter alia, agricultural mulches and garbage bags, which depending on the polymers

selected, degrade over a wide range of time. For instance, an agricultural mulch may be designed to degrade fron a few days to a few months. While a plastic garbage bag certainly will not be designed to degrade over a few days. For films, a preferred blend is polylactic acid and high molecular weight polyethylene oxide. It has been found that a high molecular weight polyethylene oxide of greater than about 100,000 molecular weight blended with a polylactic acid having a molecular weight in the range of from about 25,000 to approximately 100,000 provides a superior film. Particularly, it has been found that when the high molecular weight polyethylene oxide is present as a blend or alloy in the range of from about 2% by weight to about 50% by weight of the total polymer material, a superior film occurs. It should be understood that this is not a copolymer as previously discussed, but rather is a physical blend or alloy of polylactic acid and a high molecular weight polyethylene oxide wherein a copolymer is not formed. However, these particular blends of polylactic acid, modified as previously taught or with the addition of a glycolic acid monomer or unmodified and high molecular weight polyethylene oxide provide films having superior physical properties.

Further, when used as a film for trash bags and the like, the film can be designed so as to degrade without the presence of UV light such as in conditions which occur in landfills.

While there has been disclosed what is considered to be the preferred embodiment of the present invention, it is understood that various changes in the details may be made without departing from the spirit, or sacrificing any of the advantages of the present invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A water degradable modified polylactic acid polymer comprising: a co-polymer of monomers of lactic acid and a modifying monomer selected from the class consisting of ethylene and polyethylene glycols, propylene and polypropylene glycols, p-dioxanone, 1,5 dioxepan-2-one, 1,4-oxathialan-2-one, 1,4-dioxide and mixtures thereof, wherein said ethylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein said propylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein said p-dioxanone, 1,5 dioxepan-2-one or said 1,4-oxathialan-2-one, 4, 4-dioxide is present in the range of from about 2% by weight to about 40% by weight, said modifying polymer not exceeding about 40% by weight of said modified polylactic acid polymer.

2. The water degradable modified polylactic acid polymer of claim 1, wherein the molecular weight of the copolymer is greater than about 20,000.

3. The water degradable modified polylactic acid polymer of claim 1, wherein the molecular weight of the copolymer is in the range of from about 20,000 to about 100,000.

4. The water degradable modified polylactic acid polymer of claim 3, wherein said polymer is present as a coating on particulates selected from a class consisting of seeds, seedlings, pesticides, herbicides, fertilizers and mixtures thereof.

5. The water degradable modified polylactic acid polymer of claim 4, wherein said polymer coating has a thickness in the range of from about 0.25 microns to about 4 microns.

6. The water degradable modified polylactic acid polymer of claim 1, wherein the polymer is in the form of a thin sheet and has a molecular weight greater than about 25,000.

7. The water degradable sheet material of claim 6, wherein the molecular weight is in the range of from about 25,000 to about 100,000.

8. The water degradable modified polylactic acid polymer of claim 1, wherein the polymer is mixed with a fertilizer, pesticide, herbicide, seedling, seeds and mixtures thereof to form a dissoluble matrix therefor.

9. A water and UV degradable polylactic acid polymer comprising: a co-polymer of polylactic acid and a modifying monomer selected from the class consisting of p-dioxanone present in an amount up to about 20% by weight, 1,5 dioxepan-2-one present in an amount up to about 20% by weight, and 1,4 oxathialan-2-one, 4,4-dioxide present in an amount up to about 20% by weight, or mixtures thereof, said modifying monomer being present in an amount not greater than about 20% by weight.

10. The water and UV degradable polylactic acid copolymer of claim 9, wherein the molecular weight of the copolymer is greater than 20,000.

11. The water and UV degradable polylactic acid copolymer of claim 10, wherein the molecular weight of the copolymer is in the range of from about 20,000 to about 100,000.

12. The water and UV degradable polylactic acid copolymer of claim 11, wherein said copolyner is present as a coating on particulates selected from a class consisting of seeds, seedlings, pesticides, herbicides, fertilizers and mixtures thereof.

13. The water and UV degradable polylactic acid copolymer of claim 12, wherein said copolymer coating

has a thickness in the range of from about 0.25 microns to about 4 microns.

14. The water and UV degradable polylactic acid copolymer of claim 11, wherein the copolymer is in the form of a thin sheet and has a molecular weight greater than about 25,000.

15. The water and UV degradable polylactic acid copolymer of claim 11, wherein said copolymer is present as a matrix for an active ingredient selected from the class consisting of seeds, seedlings, pesticides, herbicides, fertilizers and mixtures thereof.

16. The water and UV degradable polylactic acid of claim 15, wherein the matrix is present in the range of from about 2% by weight to about 40% by weight of the matrix and active ingredient combination.

17. A water degradable blend of materials comprising a blend of polylactic acid and high molecular weight polyethylene oxide wherein the high molecular weight polyethylene oxide is present in the range of from about 2% by weight to about 50% by weight.

18. The water degradable blend of materials of claim 17, wherein the high molecular weight polyethylene oxide has a molecular weight greater than about 100,000 and the polylactic acid has a molecular weight of greater than about 20,000.

19. The water degradable blend of materials of claim 17, wherein said blend is present as a coating on or a matrix containing particulates selected from a class consisting of seeds, seedlings, pesticides, herbicides and fertilizers.

20. The water degradable blend of claim 17, wherein the polylactic acid polymer is modified with a monomer selected from the class consisting of

glycolic acid, ethylene and polyethylene glycols, propylene and polypropylene glycols, p-dioxanone, 1,5 dioxepan-2-one, 1,4-oxathialan-2-one, 1,4-dioxide and mixtures thereof, wherein the modifying monomer is present in the range of up to about 40% by weight of the combined polylactic acid and modifying monomer.

21. The water degradable blend of materials of claim 20, wherein the material is in sheet form and the molecular weight of the modified polylactic acid is greater than 25,000.

22. A method of applying an active material selected from the class of seeds, seedlings, pesticides, herbicides, fertilizers and mixtures thereof to an agricultural site comprising providing a copolymer of monomers of lactic acid and a modifying monomer selected from the class consisting of ethylene and polyethylene glycols, propylene and polypropylene glycols, p-dioxanone, 1,5 dioxepan-2-one, 1,4-oxathialan-2-one, 4,4-dioxide and mixtures thereof, wherein said ethylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein said propylene glycol is present in the range of from about 5% by weight to about 40% by weight, wherein said p-dioxanone, 1,5 dioxepan-2-one or said 1,4-oxathialan-2-one, 4,4-dioxide is present in the range of from about 2% by weight to about 40% by weight, said modifying polymer not exceeding about 40% by weight of said modified polylactic acid polymer, forming a combination of said copolymer and said active ingredients wherein the active ingredients are present in the range of from about 60% to about 98% by weight of the combination, and applying the combination to the agricultural site.

23. The method of claim 22, wherein said combination is a film or sheet material used as an agricultural mulch.

24. The method of claim 22, wherein the active ingredient is a seed and the copolymer is present as a coating which degrades in the field to provide oligomers of lactic acid.

25. The method of claim 22, wherein the active material used is fertilizer and the modified polymer is a matrix therefor present in the range of from about 2% by weight to about 10% by weight.

26. The method of claim 25, wherein the modified copolymer is present in the range of from about 2% by weight to about 5% by weight.

27. The method of claim 22, wherein the active ingredient is a pesticide and the copolymer is a matrix therefor present in the range of from about 2% by weight to about 40% by weight.

28. The method of claim 27, wherein the copolymer is present in the range of from about 5% by weight to about 10% by weight.

29. The method of claim 22, and further comprising the step of waiting for a period of time for the copolymer to degrade upon exposure to light and moisture to provide a variety of oligomers including growth promoters.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/04684

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61K 31/365,C08G 63/08, 63/91; C08L 51/00, 67/00
US CL :424/78,462; 525/415; 528/354,355,357

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 424/78,462;525/415/528/354,355,357

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPTO APS-BIODEGRADABLE LACTIC ACID POLYMER , FERTILIZER, PESTICIDE, HERBICIDE.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,033,938 (AUGURT), 05 JULY 1977 COL. 5, LINE 5 IN SEQ. COL. 13, LINES 35-50, EXAMPLES.	1-16,22-28
Y	US,A, 4,861,627 (MATHIOWITZ), 29 AUGUST 1989, COL.3, EXAMPLES.	1-16,22-28
A	US,A, 4,272,398 (JAFFE), 09 JUNE 1981	1-16,22-28
A	US,A, 4,767,627 (CALDWELL), 30 AUGUST 1988	1-16,22-28

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
10 SEPTEMBER 1992	30 OCT 1992
Name and mailing address of the ISA/ Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer SHELLEY A. WRIGHT Telephone No. (703) 308-2351

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/04684

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims No.: 29
because they relate to subject matter not required to be searched by this Authority, namely:

Claim 29 recites an obvious process of nature. Applicant is not setting forth positive process steps but rather for nature to take its course.

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Extra Sheet.

1. [X] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims. (Telephone Practice)

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any addtional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention frist mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I, Claims 1-16 and 22-28 drawn to polylactic acid polymer, articles coated therewith and a method of using said articles, classified in class 528/359.

Group II. Claims 17-21 drawn to polylactic acid polymer blended with a polyethylene oxide and articles coated thereof, classified in class 525/415.

Invention I is drawn to specific lactic acid based polymers while Invention II is drawn to any polylactic acid based polymers.

These two inventions do not meet the requirements for Intermediate and Final Product because the basic chemical structures as well as the final products are different.